Instructions, notes, and hints:

You may make reasonable assumptions and approximations in order to compensate for missing information, if any. Provide the details of all solutions, including important intermediate steps. You will not receive credit if you do not show your work. Use SI units, unless others are specified. If you use Matlab to make difficult or time-consuming calculations, include a commented print-out of the file or screen display that shows your work.

Assignment:

1. A receiver system is designed to detect SSB (single sideband, suppressed carrier) signals in the 14.000-14.350 MHz band and has an overall standard noise figure of 9 dB. Assuming that a minimum output SNR of 3 dB at the loudspeaker is necessary for an average person to understand a human voice, what is the MDS (at the input, in dBm) of the receiver? The receiver operates at a temperature of 290 K and has an input RF filter with a 3-MHz bandwidth, an IF filter with a 2.5-kHz bandwidth, and an audio low-pass filter with a cut-off frequency of 10 kHz. The overall gain of the receiver from the antenna connector to the loudspeaker is 120 dB.

2. Two −20-dBm signals at 110 MHz and 120 MHz are applied to the input of a real amplifier that has the following specifications:

   Input and output impedance: 50 Ω
   Input and output filter pass bands: 80-150 MHz
   Gain: 20 dB (neglect roll-off within filter pass band)
   Noise figure: 7 dB
   Third-order output intercept point: +25 dBm
   1-dB compression point: +14 dBm

   a. What are the output levels (in dBm) of the first-order products? Would gain compression be an issue in this case?
   b. What are the output levels (in dBm) of the third-order (IM3) products?
   c. Repeat Part b for the case when both input signal levels rise to −5 dBm.
   d. Are significant second-order (IM2) products likely to appear at the output of the amplifier at either power level? Why or why not?

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3. Suppose that a real amplifier is operated at a temperature of 290 K and has the following specifications, some of which are determined using a two-tone IMD test:

Input and output impedance: 50 Ω
Input and output filter pass-bands: 100-1000 MHz
Gain: 10 dB (neglect roll-off within the filter pass-band)
Noise figure: 5 dB
Third-order output intercept point: +40 dBm
1-dB compression point: +28 dBm

a. What is the output noise floor referred to the input (\(P_{NO}\)) of the amplifier?
b. Assuming that a minimum output SNR of 10 dB is required for the particular application in which the amplifier is to be used, what is the spurious-free dynamic range (SFDR) of the amplifier (in dB) under the same conditions as the two-tone test?
c. Repeat parts a and b for the case when the input and output filter pass-bands are reduced to 800-900 MHz.